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IMPLICATIONS OF MODERN COMPUTER DISPLAY TECHNOLOGY,(U)

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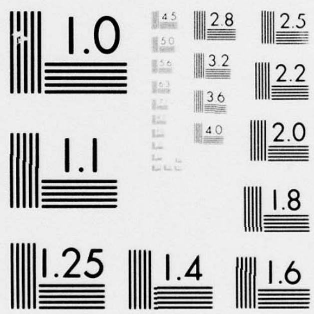

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6 IMPLICATIONS OF MODERN COMPUTER DISPLAY TECHNOLOGY,

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INTRODUCTION *

The past decade has seen substantial improvements in our ability to compute and in our ability to display the results of computations to human beings. Advances in computing have come both from improvements in integrated circuit technology and improvements in our understanding of and ability to produce complex software systems. Advances in display technology have come both from improved display devices and improved algorithms to display realistic pictures of complex objects. We have reached the point where it is technologically possible to display almost anything the human mind can conceive. The principal problem in using computing and display system is in deciding what they should do. Given a clear understanding of a specific computing task one can hire any of a number of hardware and software systems houses to produce the desired machine and software systems.

Most of the difficulty in computing systems today comes about in the specification writing stage. A new user of a complex computing system usually has a very unclear idea of what it can do for him. Installation of complex

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*This paper is adapted from material originally reported by Rand to the Office of Naval Research under Contract Number N00014-75-C-1030.

computing machinery changes the very nature of the organizations which it serves, often in unanticipated ways. It is, therefore, very difficult to establish in advance clear specifications for computing equipment. The power of computing systems stems from their complexity. The complexity of the systems itself makes it very difficult to specify and test them. Example after example can be found where inadequate specifications have led to useless systems or where changes in specifications have led to enormous cost overruns during the system construction. A major problem in obtaining computing equipment is the problem of "what do I want?"

THE NAVY'S APPROACH TO COMPUTER PROCUREMENT

The approach which the Navy and many other government agencies have typically taken in computer hardware procurement is to treat computers like other military hardware. Specifications for procurements are written by the materiel procurement side of the Navy. Systems are delivered to the Fleet as complete systems just as ships, airplanes, guns, ammunition, food, clothing, fuel, and other materiel are specified and delivered.

To some extent the Navy has also tried to specify and deliver software systems to the Fleet. Treating software systems as materiel has been less successful, for the software in a computer specifies exactly what it is to do and must often be tailored to meet specific exigencies of the specific Fleet unit which it serves. Therefore, there has been some opportunity made for Fleet units to have some direct hand in the procurement and modification of their own software systems. The Naval Security Group, (NSG) for example, and the Fleet Combat Data System Support Activity (FCDSSA) are examples of operating units which have substantial software capability.

PROGRESS OF TECHNOLOGY

Meanwhile the technological advances in integrated circuitry have begun to increase the complexity of computing

hardware enormously. Detailed specification for a pocket calculator, for example, can be exceedingly complex. It will be within the capability of the technology in a few years to produce a hardware device the size of a pocket calculator which contains volumes of data about Navy operating procedures. The specification of such a device would have to include the entire operating procedure which it knows!

The distinctions between hardware and software are becoming harder and harder to detect. The advent of read only memories can make it impossible to change the memory content after delivery and therefore puts a much higher burden of correctness on those who specify and procure the systems.

IMPLICATIONS FOR NAVY PROCUREMENT OF COMPUTING EQUIPMENT

I believe that the increasing complexity of computing equipment will ultimately force a change in Navy procurement procedures. Operating units of the Fleet will have to be given greater control over the specification and modification of the equipment that they operate as those equipments begin to embody more and more computing devices which implement the Fleet operating procedures. The paragraph below shows a hypothetical but quite feasible example.

Example:

In 1985 radios will be available which implement not only communications functions but also contain minicomputers which cause them to operate according to Fleet radio

procedures. When Fleet radio procedures today are written in manuals and read by human beings who turn switches on the communications gear, new communications sets will partly automate this function. A fleet commander may be perfectly willing to have somebody else specify, purchase and deliver his radios, but no fleet commander in his right mind will release control of the procedures by which that radio is operated. For times of emergency or for peculiar operations the fleet commander will need the ability to change the operating procedures implemented by his radios just as he can now change the operating procedures implemented by the people of his command. It will simply not be possible for a separate material procurement agency to provide adequately for a commander's real needs with equipment which includes not only the communications but the communication procedure functions.

RECOMMENDATIONS

It seems to me that advances in the computer technology will continue to increase the complexity of the devices in use in the Fleet. This increase in complexity will require not only a higher skill level of Fleet operating personnel to understand the use and operation of these devices but also a higher degree of control by Fleet personnel of the specific functions implemented in the devices. We need to consider carefully how the specifications for complex devices which include computing elements are written. We need to insure that those who must use these devices have an adequate say in the particular form that they take. Unfortunately this is an administrative rather than a technical recommendation and I must confess that I am not quite sure to whom it should be addressed.

FUTURE TECHNICAL WORK

On the technical side, it seems possible to me to think in terms of the information content of machines. From a user's point of view, the information content of a machine is partly determined by the number of ways in which he may use it. From a user's point of view, a car radio has very low information content since its only controls are ON-OFF, VOLUME, and TUNING. Similarly, from a navigator's point of view, a ship has very low information content since its only navigational controls are POWER and STEERING. From a weapons point of view, of course, a ship is more complex but still not nearly so complex as a computing system. The complexities of operating the weapons systems on a ship are largely built into the crew and can, therefore, be changed by the captain through weapons drills and training exercises of various kinds.

I believe that from some quantitative measures of the information content of equipment could be developed. Such measures would properly ignore the complexity of the design of the equipment and concentrate on the use of the equipment. Properly defined, such measures should enable one to predict the amount of training which would be required to use the equipment effectively and might also predict the number of pages of specifications which would be required to define such equipment for procurement purposes.

Every organizational barrier provides an information flow

channel with limited bandwidth. Measures of the information content of equipment would be useful in predicting how specifications for such equipment might flow from one organization to another. I believe that very complex equipments can only be specified in detail by the organization which uses them since the information loss in transmitting a specification from one organization to another can be large enough as to destroy the utility of the complex equipment. I believe that the number of equipments which the Navy will procure at this level of complexity will increase from a handful today to many thousands in the near future as microcomputing elements begin to be built into nearly every artifact of Naval utility.

Appendix A

SEMINAR

At the request of Marvin Denicoff, Program Director of Information Systems, Office of Naval Research, I arranged and chaired a two-day conference on computer graphics on April 6-7, 1976, in Washington, D.C.

Listed below are the four major topics, chairman of each session, and the speakers:

I. ENGINEERING APPLICATIONS

Chairman: Richard F. Riesenfeld
Computer Science Department
University of Utah
Salt Lake City, Utah 84112

Henry N. Christiansen
Department of Civil Engineering Science
368 Engineering Science Technology Building
Brigham Young University
Provo, Utah 84602

Elizabeth Cuthill
Acting Head, Computer Sciences Division
Computation and Mathematics Department
Naval Ship Research and Development Center
Bethesda, Maryland 20854

A. Robin Forrest
University of East Anglia
School of Computing Studies
University Village, Norwich NR4 7TJ
UNITED KINGDOM

H. Nowacki
Fachgebiet Schiffsentwurf
Institut Fur Schiffstechnik
Technische Universitat Berlin
Salzufer 17/19
1 Berlin 10
WEST GERMANY

II. SCIENTIFIC APPLICATIONS

Chairman: Kent Wilson
Department of Chemistry
University of California - San Diego
P.O. Box 109
La Jolla, California 92037

Eduardo Macagno
Department of Biological Sciences
Columbia University
New York. New York 10027

Joel L. Sussman
Biochemistry Department
Duke University Medical Center
Durham, North Carolina 27710

III. ADVANCED GRAPHICS RESEARCH

Chairman: Nicholas Negroponte
Massachusetts Institute of Technology
School of Architecture and Planning
77 Massachusetts Avenue
Cambridge, Massachusetts 02139

Edwin Catmull
Computer Graphics Laboratory
New York Institute of Technology
P.O. Box 170
Old Westbury, New York 11568

George Hoover (Consultant)
746 Almareal Drive
Pacific Palisades, California 90272

Alan Kay
XEROX Palo Alto Research Center
3333 Coyote Hill Road
Palo Alto, California 94304

IV. SIMULATION

Chairman: Milton Fischer (Retired)
2316 Chinook Trail
Maitland, Florida 32751

Marvin Bunker
General Electric Company
P.O. Box 2500
Daytona Beach, Florida 32015

David C. Evans, President
Redifon/E&S Computer Corporation
3 Research Road
Salt Lake City, Utah 84112

Gordon Handberg
Dept. 0035, Bldg. 096
McDonnell Douglas Electronics Company
P.O. Box 426
St. Charles, Missouri 63301

Steve Mori
The Singer Company
1077 E. Arques Avenue
Sunnyvale, California 94086

Appendix B

SITES VISITED

FASOTRAGRUPAC, San Diego, California
 Cdr. John Hulme
 Cdr. Walker, Training Officer of Fleet Introductory Team

Fleet Combat Direction Systems Support Activity (FCDSSA), San Diego
 Charles Coble
 Mike Griswald
 Robert Kolb
 James F. Melton (a Navy Lieutenant)
 Donald Mudd
 Captain Herbert Reichert, Commanding Officer of FCDSSA
 T. M. Widrig, Technical Director of Naval Tactical Data Systems

NAMTRADETS, San Diego, California
 Chief Miller
 Cdr. Richard Mudgett

Naval Centerville Facility, Ferndale, California
 Lt. Cdr. James Faust

Naval Intelligence Support Center, Washington, D.C.
 Edward C. Newbegin

Naval Undersea Center, San Diego, California
 William Squire